DARK ENERGY SURVEY

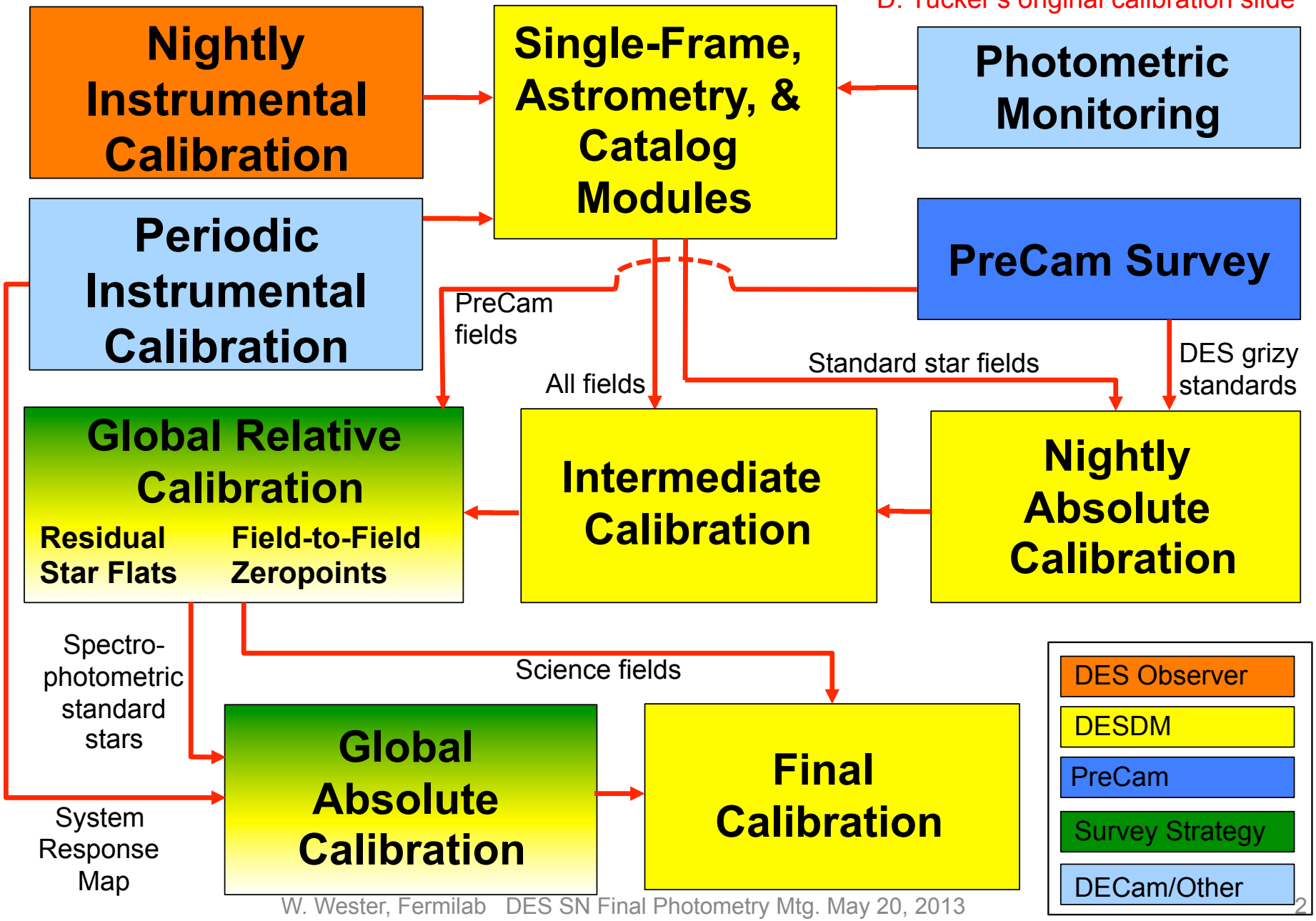
DES Calibration Overview

Photometric Goals and Requirements

- SV and 1st Year:
  - All-sky internal: 3% rms
  - Absolute Color: 3% (*g-r*, *r-i*, *i-z*); 4% (*z-Y*)
  - Absolute Flux: 3% in *i*-band (relative to BD+17 4708)
- 2nd Year:
  - All-sky internal: 2% rms
  - Absolute Color: 2% (*g-r*, *r-i*, *i-z*); 3% (*z-Y*)
  - Absolute Flux: 2% in *i*-band (relative to BD+17 4708)
- Full Survey: (from Science Requirements DocDB 20)
  - All-sky internal: 2% rms (Goal of 1%)
  - Absolute Color: 0.5% (*g-r*, *r-i*, *i-z*); 1% (*z-Y*)
  - Absolute Flux: 0.5% in *i*-band (relative to BD+17 4708)

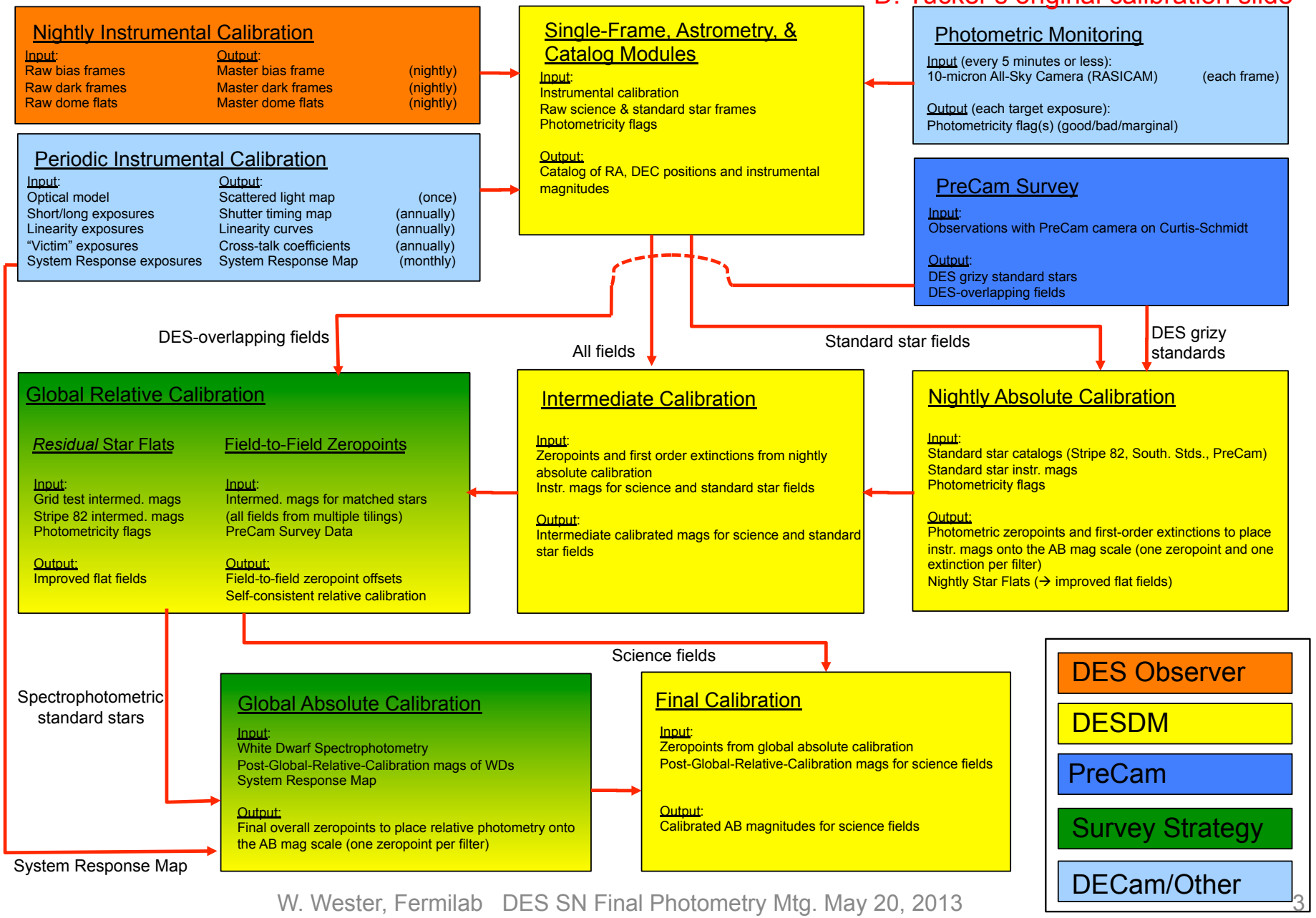
DES Photometric Calibrations Flow Diagram (v4.1)

D. Tucker's original calibration slide



DES Photometric Calibrations Flow Diagram (v4.1)

D. Tucker's original calibration slide



DES Calibrations Plan in 6 Points

D. Tucker's Presentation DocDB 7235

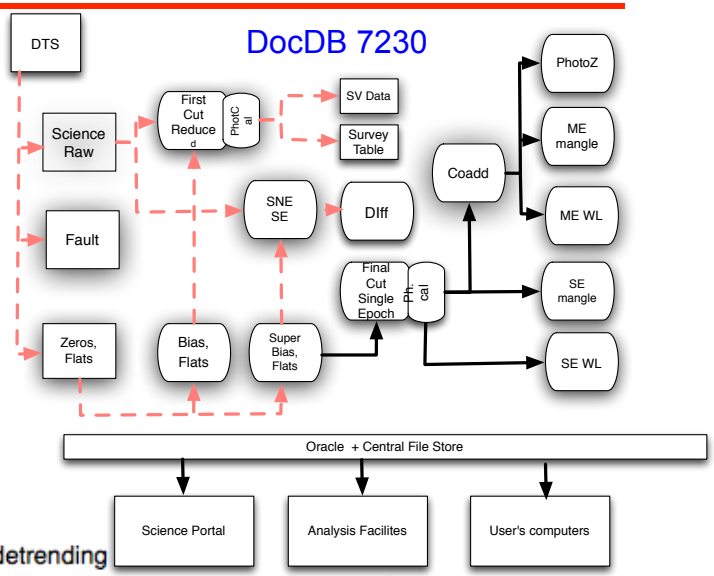
DARK ENERGY SURVEY

1. Instrumental Calibration (Nightly & Periodic): Create biases, dome flats, linearity curves, cross-talk coefficients, system response maps.
2. Photometric Monitoring: Monitor sky conditions with 10μm All-Sky Cloud Camera and the GPS and atmCam atmospheric transmission monitors.
3. PreCam Survey: Create a network of calibrated DES *grizy* standard stars for use in nightly calibrations and in DES Global Relative Calibrations.
4. Nightly and Intermediate Calibrations: Observe standard star fields with DECam during evening and morning twilight and at least once in the middle of the night; fit photometric equation; apply the results to the data.
5. Global Relative Calibrations: Use the extensive overlaps between exposures over multiple tilings to tie together the DES photometry onto an internally consistent system across the entire DES footprint.
6. Global Absolute Calibrations: Use DECam observations of spectro-photometric standards in combination with measurements of the full DECam system response map to tie the DES photometry onto an AB magnitude system.

From the data management side

DARK ENERGY SURVEY

For the main survey, modules are added to the appropriate pipelines to implement calibration algorithms. These algorithms impact either the reduced etc. images or contents of the DESDM database (EXPOSURE, IMAGE, "OBJECTS", and PSMFIT tables)



Operational Pipelines:

https://cosmology.illinois.edu/confluence/display/Operations/Operational+Pipelines

- **PreCal:** process nightly calibration exposures to create calibration files for detrending
- **SuperCal:** combine calibration exposures across several nights to create high S/N calibration files for detrending
- **FirstCut:** fill out the survey table, i.e., minimal processing to determine if a raw exposure is "good enough" to be included in the survey or if it needs to be re-imaged
- **SNeSE:** basic image reduction of supernova exposures in preparation for supernova difference imaging
- **FinalCut:** single epoch reduction of images for cataloging and in preparation for coaddition
- **Photcal:** apply the PSM solution to objects cataloged in single epoch processing
- **Coadd:** multi-epoch processing of images, including coaddition and object cataloging
- **PhotoZ:** calculate photometric redshifts

SNeSE

Block	Module Name (click to see current configuration)	Operation	Science Codes (click for documentation)	Data In	Data Out	DB Tables
crosstalk	crosstalk	Apply crosstalk correction, overscan, & satmask	crosstalk.pl -> DECam_crosstalk	src (obstype = object), xtalk file	raw_obj	
imcorrect	imcorrect	Apply bias correction, flat correction	imcorrect	raw_obj, biascor, flatcor, bpm, photflatcor, pupil		
astrorefine	catalog_exposure	Calculate astrometric solution	runSExtractor.c -> SExtractor, fwhm.c create_fullscamp.pl -> fitscombine.c			
astrorefine	scamp	Ingest astrometric solution (VO Table)	runSCAMP.pl -> SCAMP			
ingest_scampqa	ingest_scampqa	Ingest astrometric solution (VO Table)	ingestSCAMPqa.pl	scamp.xml		
create_catalog	create_catalog	Create basic source catalog	runSExtractor.c --> SExtractor	reduced images, sex.config, sex.conv, sex.nnw, sex.param_nopsfex	reduced image catalogs (*_cat.fits)	selects from LOCATION
merge_table	merge_table	Merge temporary catalog table with objects table	merge_objects	none	none	selects from tmp table, inserts in OBJECTS_CURRENT
compress_files	compress_files	Compress files created during processing	compress_files	raw_obj images, reduced images	compressed raw_obj & reduced images (*.fz)	selects from LOCATION

Nightly/Intermediate Calibrations: The Photometric Equation

DARK ENERGY SURVEY

- The Photometric Equation is a simple model that fits the observed magnitudes of a set of standard stars to their "true" magnitudes via a simple model; e.g.:

$$m_{inst} - m_{std} = a_n + kX \qquad (1)$$

  - m_{inst} is the instrumental magnitude, $m_{inst} = -2.5\log(counts/sec)$ (input)
  - m_{std} is the standard ("true") magnitude of the standard star (input)
  - a_n is the photometric zeropoint for CCD n (n = 1-62) (output)
  - k is the first-order extinction (input/output)
  - X is the airmass (input)

- A refinement: add an instrumental color term for each CCD to account for small differences between the standard star system and the natural system of that CCD:

$$m_{inst} - m_{std} = a_n + b_n \times (stdColor - stdColor_0) + kX \qquad (2)$$

  - b_n is the instrumental color term coefficient for CCD n (n = 1-62) (input/output)
  - $stdColor$ is a color index, e.g., $(g-r)$ (input)
  - $stdColor_0$ is a constant (a fixed reference value for that passband) (input)
  - DES calibrations will be in the DECam natural system, but there may be variations from CCD to CCD within the DECam focal plane or over time.

D. Tucker

DARK ENERGY SURVEY

Stellar magnitudes

PSMFIT table has the a_n, k, and b_n coefficients for photometric nights where the PSM solution is derived from standard star observations taken typically at morning and evening twilight and also around 1AM.

- Each of the (u), g, r, I, z, Y filters
- typically SDSS stripe 82 star field
- low, medium, and high airmass

Note: some adjustments required, as SDSS standards are typically used (UKIDSS for Y), to put the magnitudes on the DES standard and on AB scale. Example:

. g_des = mag_psf - zeropoint + 2.5*log10(exptime) - a_ccd - b_ccd*(-0.114 - 0.530) - k*X + 0.021

where zeropoint is (almost?) always 25.000,
0.530 is the reference g-r color ("color0") used by PSM,
-0.114 is the g-r color where g_des=g_sdss_ab, and
+0.021 is the g-band AB offset for the SDSS Stripe82 standards currently used by DESDM

Comments welcome for a future more detailed presentation